CONVERTING ASYNCHRONOUS DATA INTO A STANDARD IRIG TELEMETRY FORMAT

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ABSTRACT

In recent years we have seen an increase in the use of MIL-STD-1553 buses and other asynchronous data sources used in new missile and launcher designs. The application of multiplexed asynchronous buses in missiles and launchers is very common today. With increasing application of asynchronous data sources into very complex systems the need to acquire, analyze, and present one hundred percent of the bus traffic in real time or near real time has become especially important during testing and diagnostic operations.

This paper discusses ways of converting asynchronous data, including MIL-STD-1553, into a telemetry format that is suitable for encryption, telemetering, recording, and presenting with Inter Range Instrumentation Group (IRIG) compatible off-the-shelf hardware. The importance of these designs is to provide the capability to conserve data bandwidth and to maximize the use of existing hardware. In addition, this paper will discuss a unique decode and time tagging design that conserves data storage when compared to the methods in IRIG Standard 106-96 and still maintains a very accurate time tag.

KEY WORDS

MIL-STD-1553, Converting asynchronous data, IRIG, time

INTRODUCTION

In the mid-1980's a requirement to record, decommutate and process a 1 MHz serial asynchronous data stream similar to Military Standard (MIL-STD) -1553 was presented to the LTV Missiles and Electronics Group, now Lockheed Martin Vought Systems, Test Data Group. To accomplish this goal, it was initially decided to telemeter the raw asynchronous data stream then record the telemetered data stream using an analog tape recorder. A circuit was designed and used which decoded the signal using a Harris HD-15530 CMOS Manchester Encoder-Decoder chip. The decoded data was input into a Xerox Sigma 3 computer using a parallel digital interface. Once in the computer's memory the data was available for analysis and reduction.

This method resulted in a loss of data due primarily to the analog tape recorder's lack of a low frequency response, which resulted in a signal droop, a deviation in the signal baseline between message words. Due to the signal droop, only 95 to 98 percent of the raw asynchronous data could be recovered using this method. At the time, the best frequency response available from an analog tape recorder was 40 Hz to 2 MHz. A frequency response from DC to 2 MHz was necessary to eliminate the signal droop and increase the data recovery rate to 100 percent.

A dual threshold detector, which used two operational amplifiers, each having a threshold adjustment, was designed and implemented in an attempt to eliminate the baseline droop problem. The signals output by the dual threshold detector were a bipolar 0 (BIP0) and a bipolar 1 (BIP1). Use of this circuit improved the data recovery rate to about 99%. Unfortunately, the adjustments required to make the circuit work properly were very critical, and many of our personnel, accustomed to operating digital systems, had difficulties in making the analog adjustments.

Before the 1 MHz baseline droop problem could be completely resolved the data rate for the asynchronous signal was increased to 2 MHz and a requirement to encrypt the data onboard the test vehicle was added. The necessary data encryption hardware would accept only non-return to zero level (NRZ-L) and clock inputs. To incorporate these new requirements the original effort of recording the asynchronous signal on analog tape was discontinued and a new asynchronous interface was designed and developed using experience gained from working with MIL-STD-1553 and other asynchronous data formats.

ENCODER/DECODER DESIGN REQUIREMENTS

The new asynchronous data encoder had a requirement to convert MIL-STD-1553 and similar asynchronous data streams into a standard IRIG format that could then be recorded and played back with an IRIG analog recorder. The standard IRIG format allowed the data to be telemetered, recorded, and played back at any test range, and allowed the data to be encrypted, using common methods. The new interface also required 100% data recovery.

The decoder had a requirement to convert the encoded IRIG signal back into parallel digital words. It would also distinguish the command/status words from data words and insert an identifiable 32 bit time code word each time a command/status word was decoded.

To meet the above requirements, the asynchronous signal needed to be converted into a standard IRIG NRZ-L format with an identifiable sync code. A method of encoding the asynchronous signal that retained the 20 bits per word, inserted a sync code, identified the word as a command/status word or as a data word, and retained the original 16 bits of data was devised. The logic for this encoding process is presented in Figure 1.

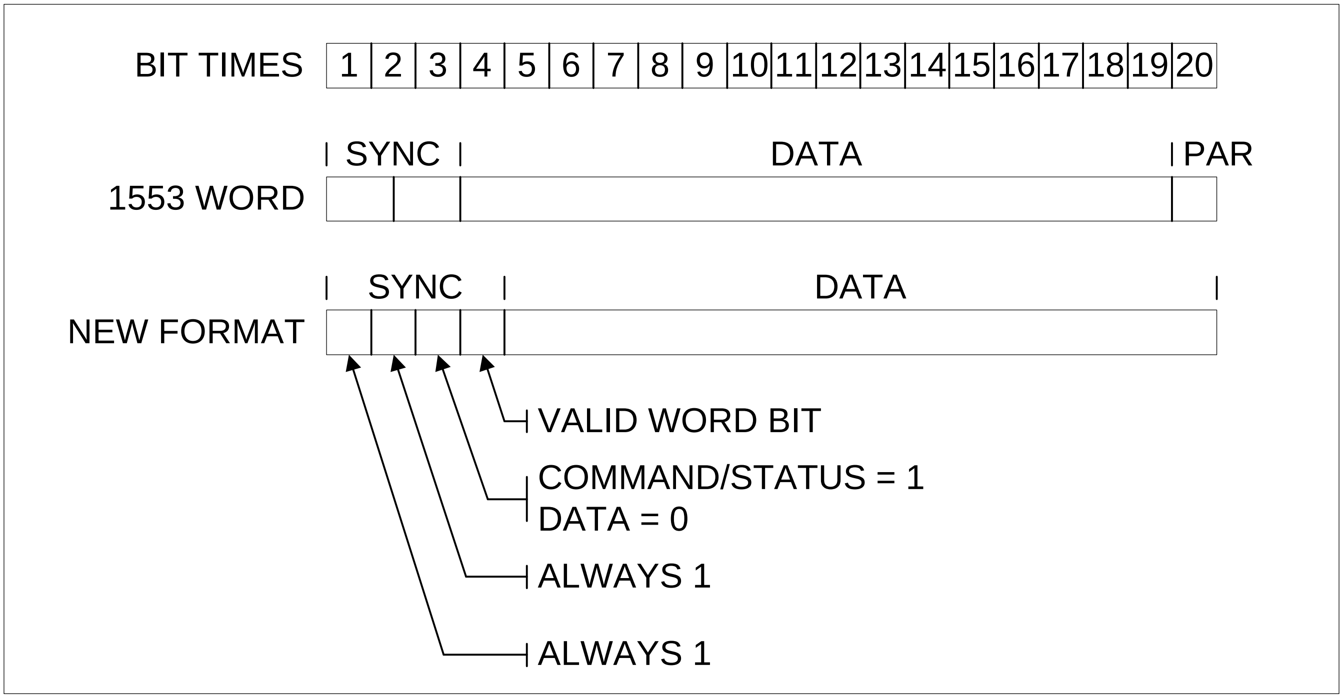

Figure 1. Word Format Conversion

ENCODING

The Harris HD-15530 was used to perform the encoding. The HD-15530 produces a command/status bit, a valid word bit, and a parallel 16 bit data word. The 16 bit data word is transferred to a 20 bit parallel to serial converter, along with the new 4 bit sync word. Data is continuously clocked through the parallel to serial converter to create a continuous synchronous data stream. The input to the parallel to serial converter is loaded at 90° clock time after at least 20 bits have been shifted since the last load and a “convert complete” signal is received from the HD-15530. Data is then shifted out as a synchronous NRZ-L word with clock. Once in the NRZ-L format the data is easily encrypted or converted into any other IRIG format and telemetered. A simple functional block diagram of the encoding circuit is presented as Figure 2.

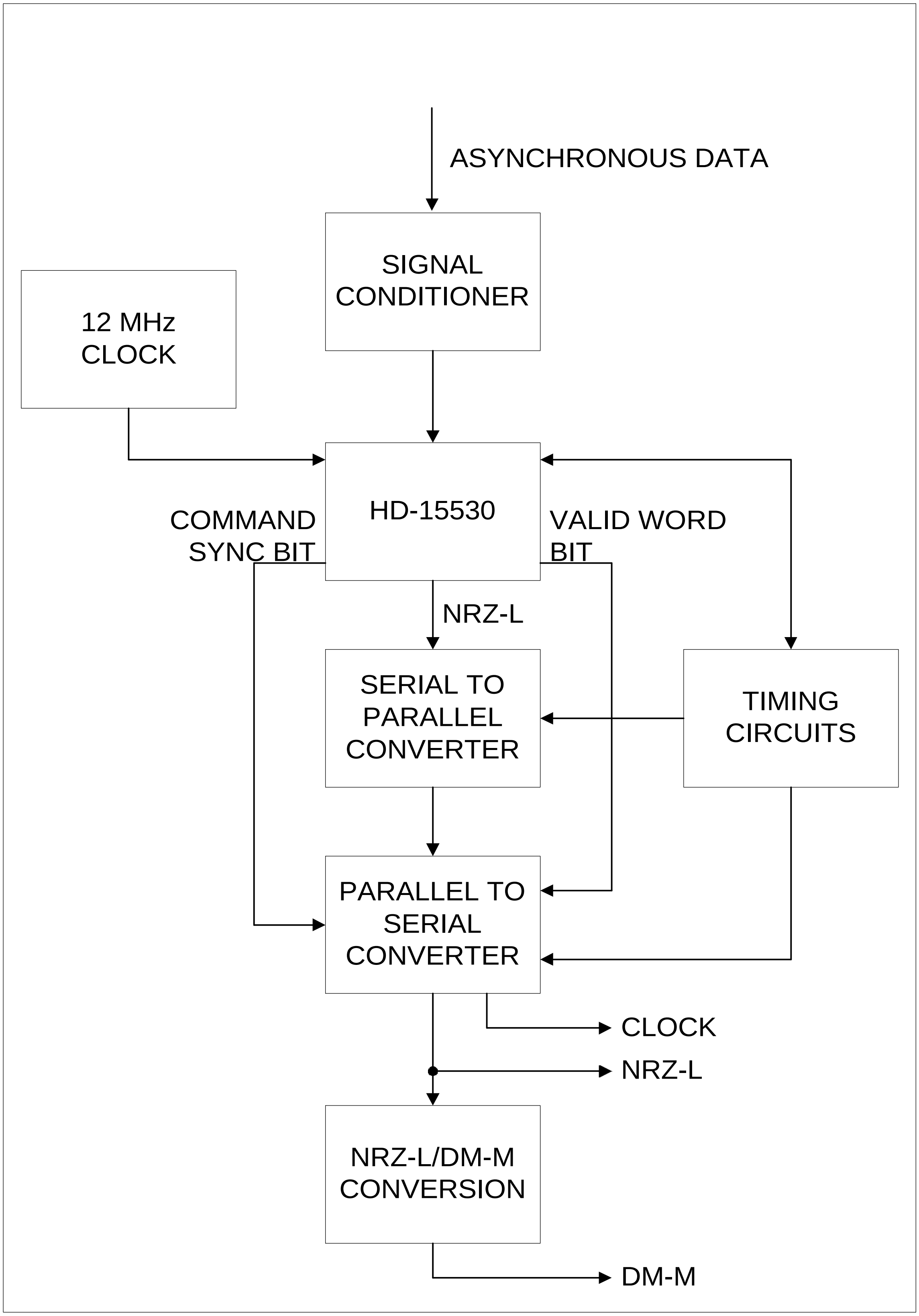

Figure 2. Block Diagram of Encoding Circuit

TRANSLATION TO DM-M

The encoded NRZ-L signal is converted to the Delay Modulation Mark (DM-M) format for recording on analog tape. DM-M is chosen because it requires the least data record bandwidth. The DM-M format theoretically requires a bandwidth slightly more than forty percent of the data bit rate (Reference 1), as shown in Figure 3. Therefore the 2 MHz bit rate data signal would require a bandwidth of 800kHz, which could easily be recorded and played back on analog recorders that have a bandwidth of 1 MHz.

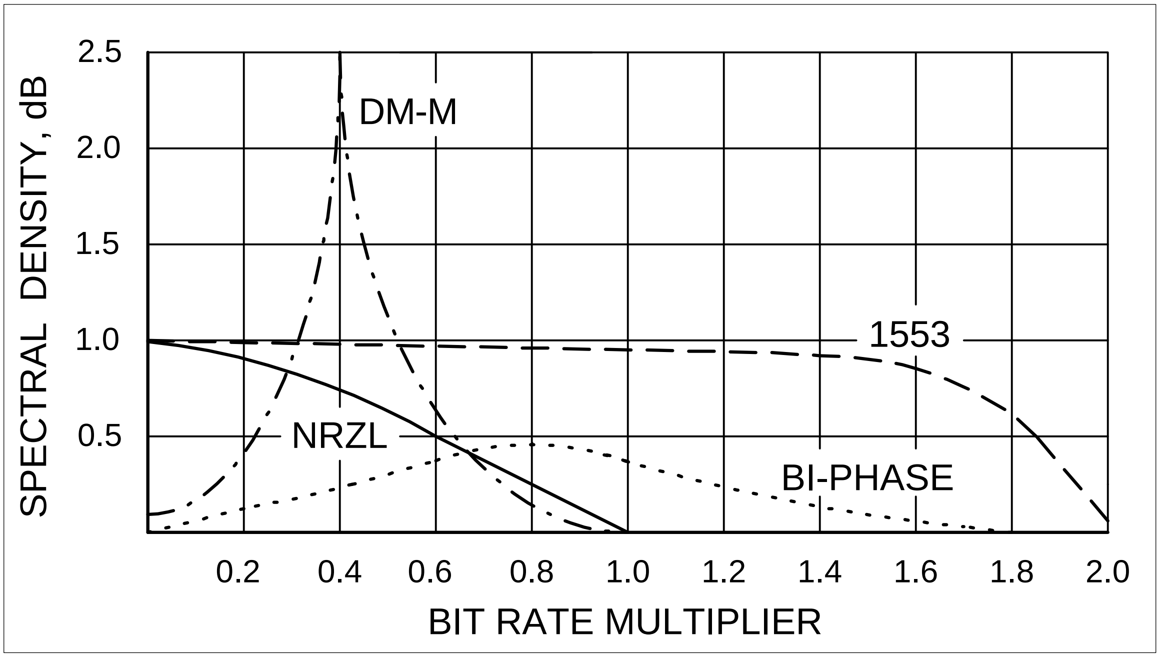

Figure 3. Approximate Power Spectral Density

TIME TAGGING

Two 16 bit time words are used to time tag the data. The first word is used to denote non-fractional time and is essentially a modified presentation of the IRIG time code. The second word is used to denote single and fractional seconds and is presented with a resolution of 32 µsec, as shown in Figure 4. This resolution has proven to be adequate for a majority of test programs. Fractional seconds are obtained by phase locking a counter to the IRIG time code and counting to 1000 between cycles of an IRIG-B time code, or counting to 100 for IRIG-A time code. If an IRIG-B time code is used then this technique allows time tagging with a resolution of 1 µsec.

BIT TIMES	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
TIME WORD A	2^1	2^2	2^3	2^4	2^5	2^0	2^1	2^2	2^3	2^4	2^5	2^0	2^1	2^2	2^3	2^4
	sec					min						hour				

BIT TIMES	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
TIME WORD B	2^5	2^6	2^7	2^8	2^9	2^0	2^1	2^2	2^3	2^4	2^5	2^6	2^7	2^8	2^9	2^0
	µsec					msec										s

Figure 4. Time Word Formats

INPUT TO COMPUTER AND DATA PROCESSING

First, the NRZ-L signal was clocked into a 20 bit serial to parallel converter. When a word sync (11X1) is detected, the 16 data bits are transferred to a parallel register. If bit 3 of the 4-bit sync code is 1, a barker code and a 32 bit time word, followed by the 16 bit data word, are input to the computer. The serial to parallel processor is reset at 270° clock time. A simple block diagram of the decoding circuit is presented as Figure 5.

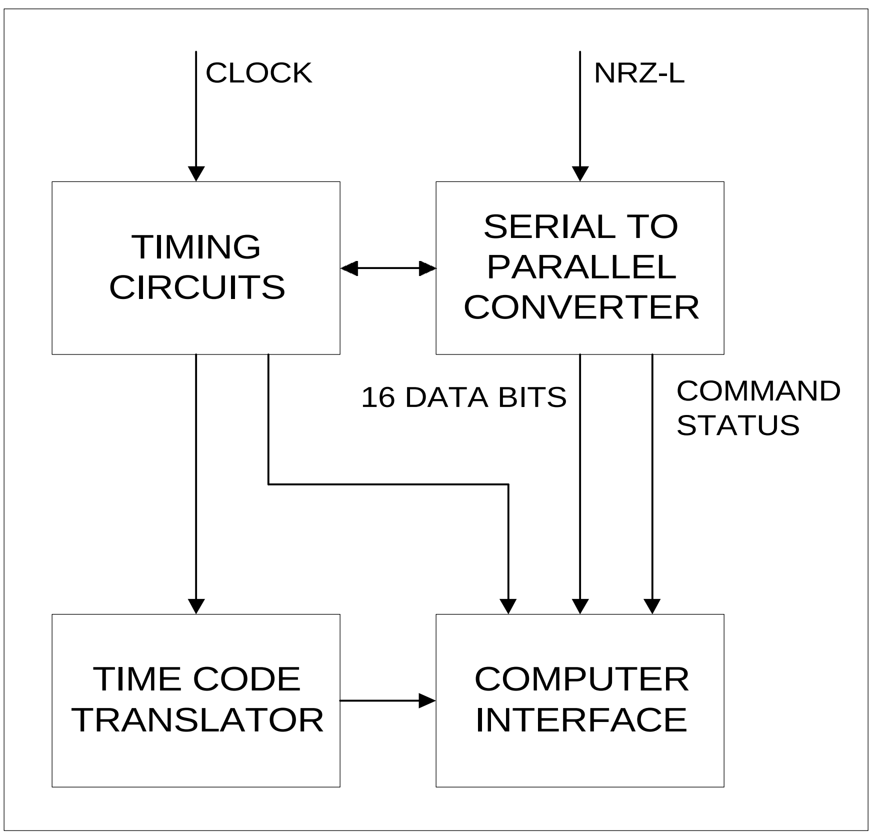

Figure 5. Block Diagram of Decoding Circuit

A Digital Equipment Corporation (DEC) MicroVAX II was the first computer interfaced with the encode/decode circuits. Data throughput of 100,000 words per second was achieved while simultaneously storing the data to disk and processing and presenting the data in real time on the data terminals.

The computing power required to process, display, and record the data has increased as the rate of data transmission has increased from about 50,000 words per second to more than 500,000 words per second. Using this encode/decode circuit design, VME based systems such as Concurrent Model 7000, Veda Itas Omega 30, and L-3 Communications Telemetry and Instrumentation System 550 are used to convert, display, store, and process MIL-STD-1553 and other asynchronous data streams, in addition to PCM and analog data, in real time.

CONCLUSION

The method of converting asynchronous signals into a standard IRIG format for recording or telemetry presented in this paper has been used for many different test programs with great success. These techniques are flexible so that they can easily be modified to address different types of asynchronous signals. The decoding and time tagging methods presented conserve data storage when compared to the methods of IRIG Standard 106-96 with minimal loss in time tag resolution.

ACKNOWLEDGMENTS

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REFERENCES

1. Schuldt, David A., “A Discussion of PCM Recording with Emphasis on the Miller Code”, Ampex Instrumentation Division.